Searches for New Physics at CDF

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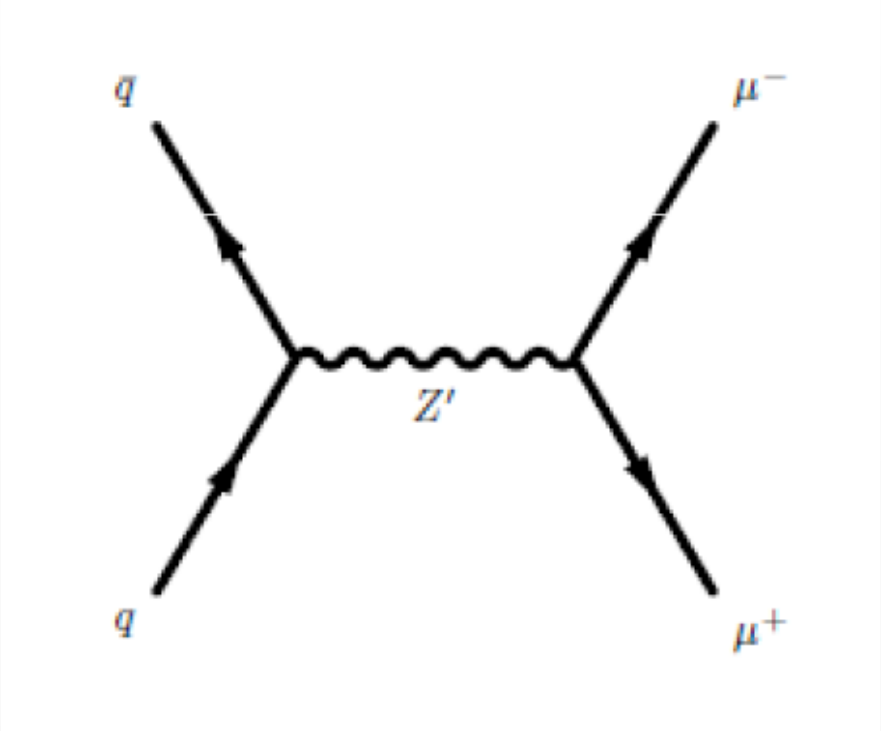
Lake Louise Winter Institute - 2011

23 February, 2011

New Physics Searches at CDF

- Searches for Resonances:
  - Search for Z′
  - Search for W′
  - Search for 3-jet resonances
- Searches for New Pair Produced Quarks:
  - t′-> tX
  - b′-> tW
- Search for anomalous production
  - In lbγMET
- See Ray Culbertson's talk on searches in photon + X signatures

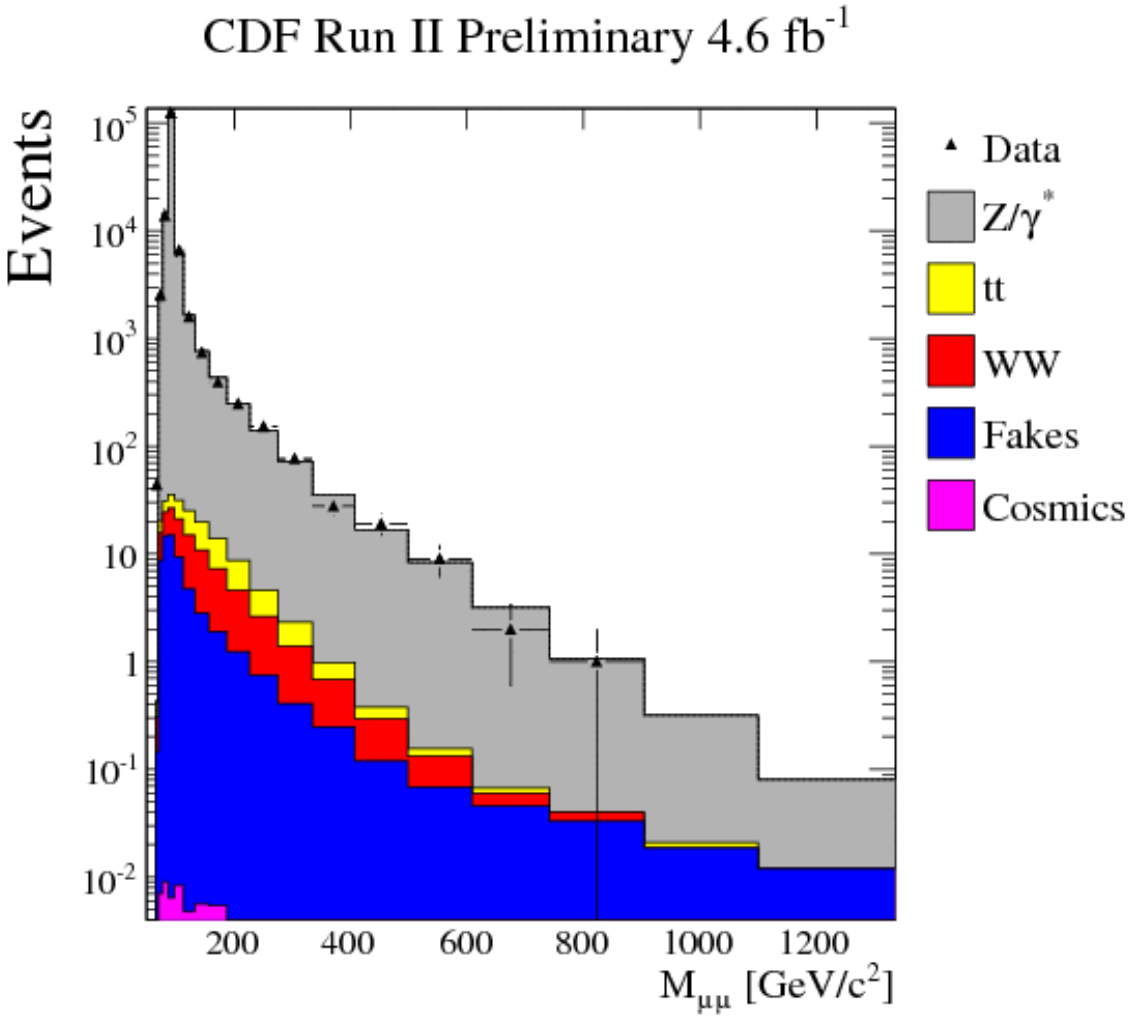
Search for Z'



- Updated result on Z'-> μμ search using 4.6 fb^{-1} dataset
- Improved (~20%) sensitivity by using the Matrix Element technique
- More generic statistical treatment :
- - Designed to be sensitive to any bump in the di-muon mass spectrum (Z', RS Gravitions – spin2, RPV ν) independent on the cross section for new physics signal

- Event Selection:
  - Two isolated μ: p_T > 30 GeV
  - m(μμ) > 130 GeV
  - Cosmic veto

Search for Z'

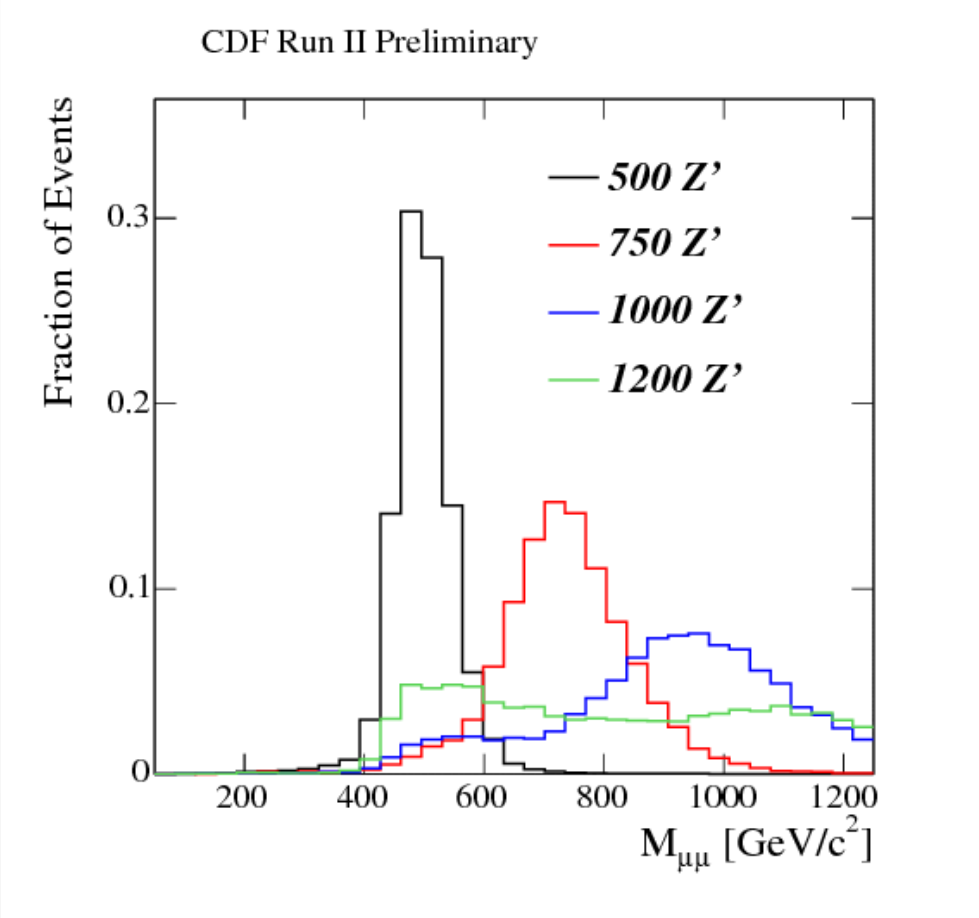


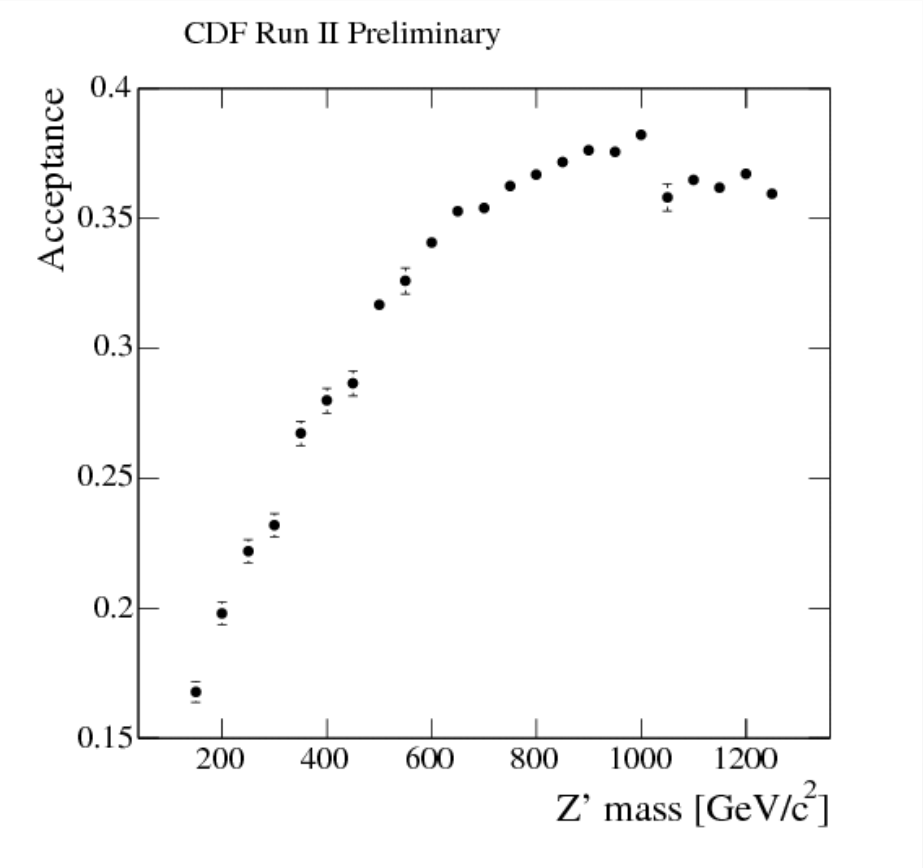
- NNLO Drell-Yan normalized to low mass
- WW and tt from MC
  (46 ± 2 events)
- Fakes and cosmic using data-driven methods
  (8 ± 1)

- 1851 ± 90 events expected
- 1813 observed

Search for Z'

- Use PYTHIA for spin-1 Z' and Madgraph for spin-0 and spin2
- Largest uncertainty due to PDFs
- Shape distortion and acceptance drop due to small PDF at ~ 1 TeV

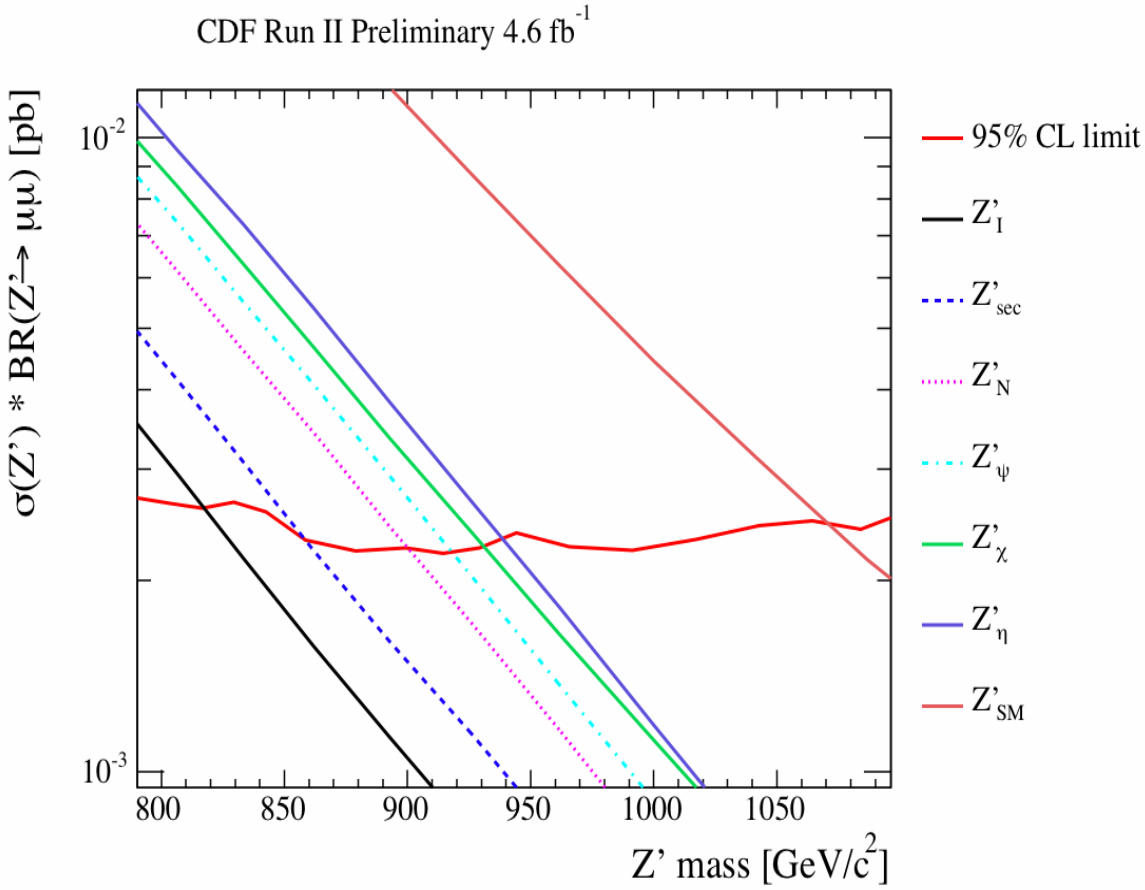




Search for Z'

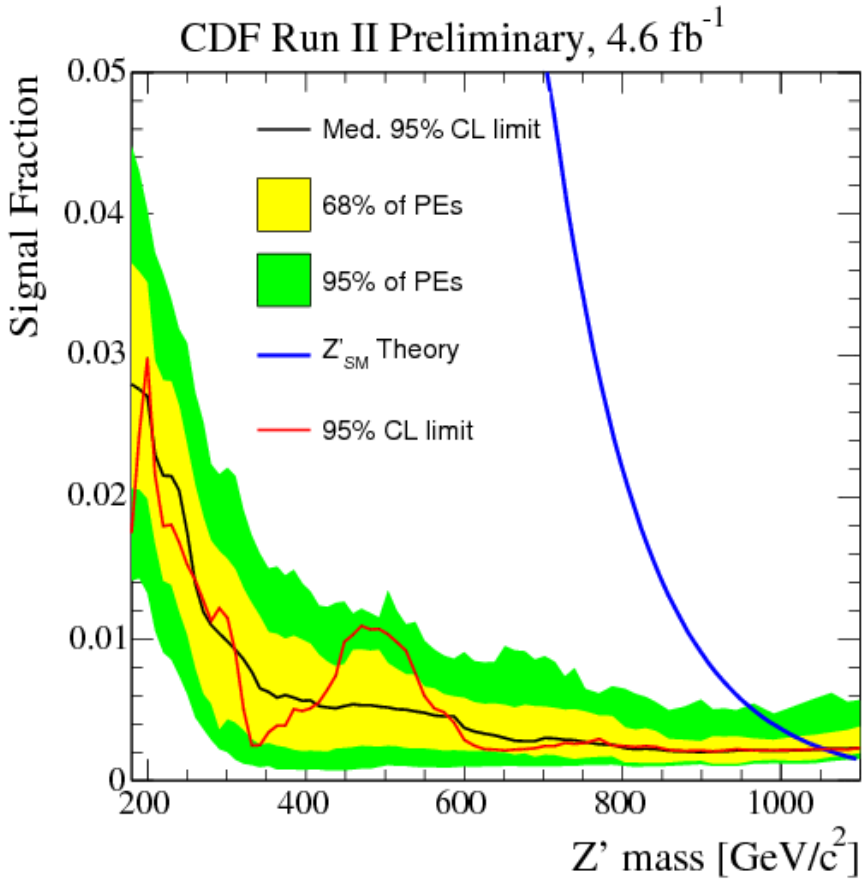
- Observed limits for various Z' scenarios, exclude Z' with SM couplings below 1.07 TeV at 95% C.L.

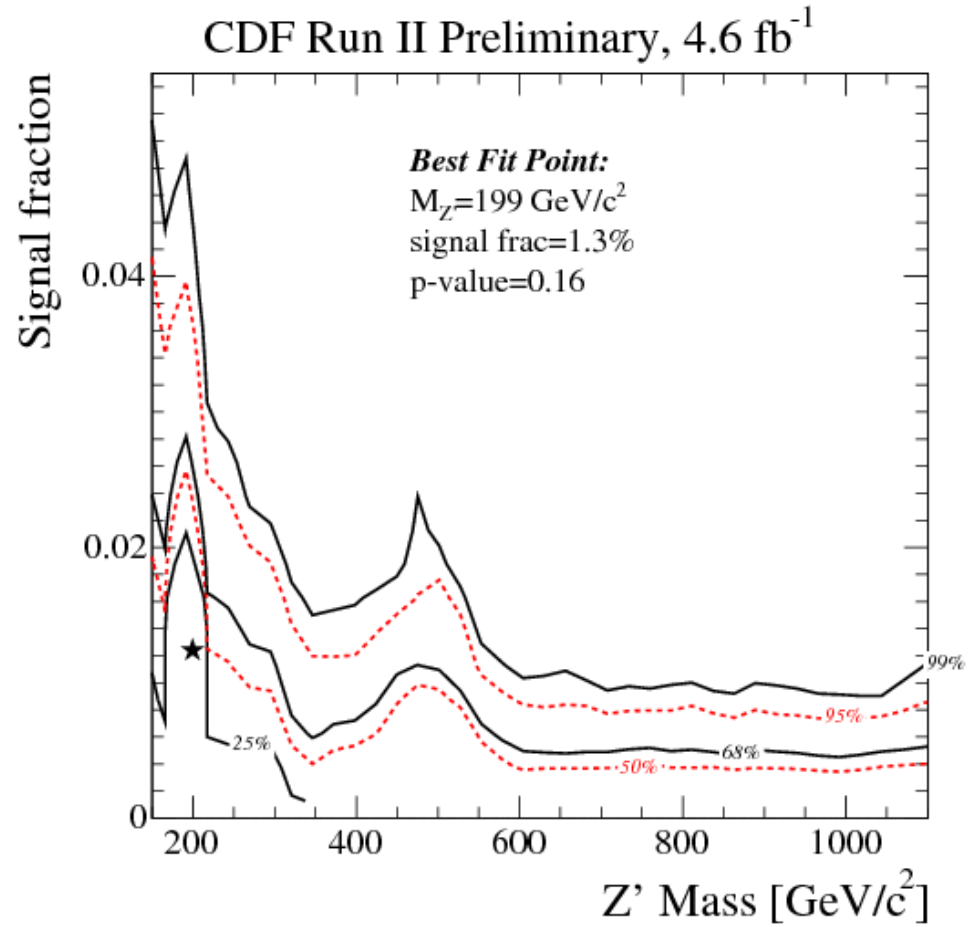
Model	Mass Limit (GeV/c^2)
Z'_l	817
Z'_{sec}	858
Z'_N	900
Z'_ψ	917
Z'_χ	930
Z'_η	938
Z'_{SM}	1071



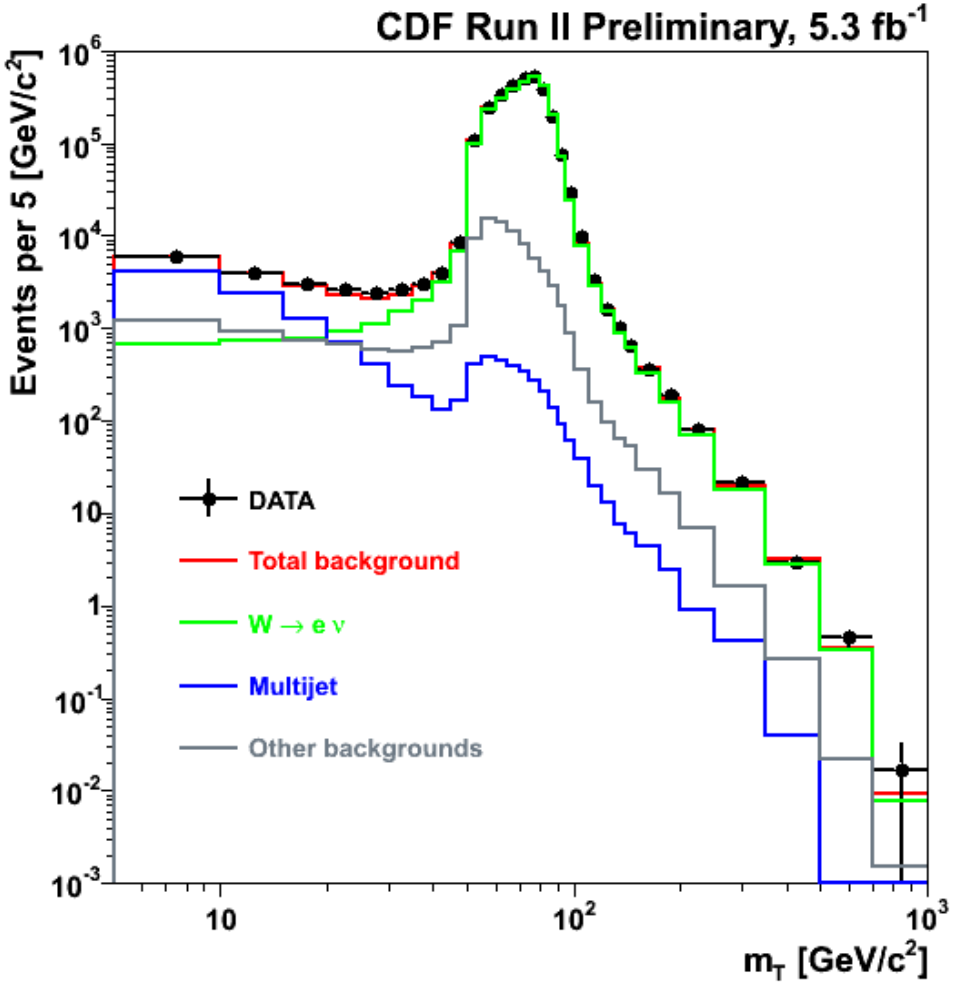
Search for Z'

- 2D analysis of ($M_{Z'}$, Z' fraction - independent)





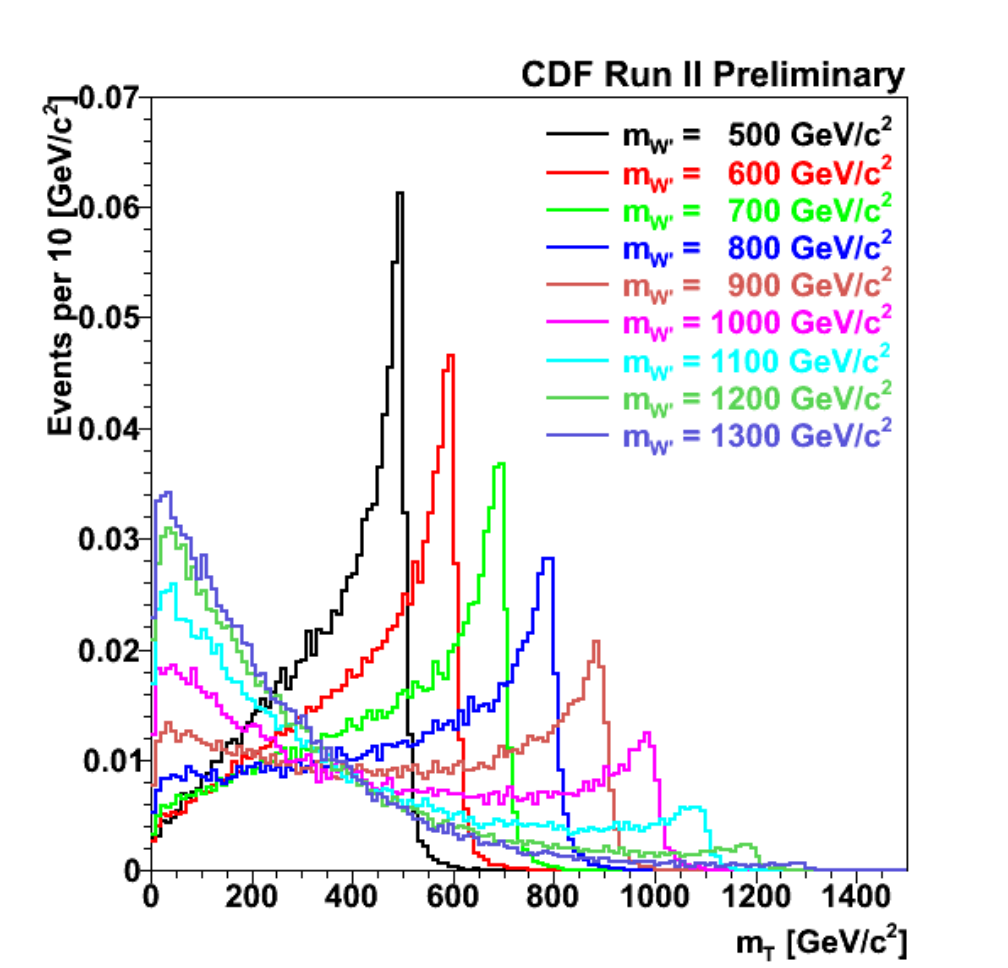
W' Search



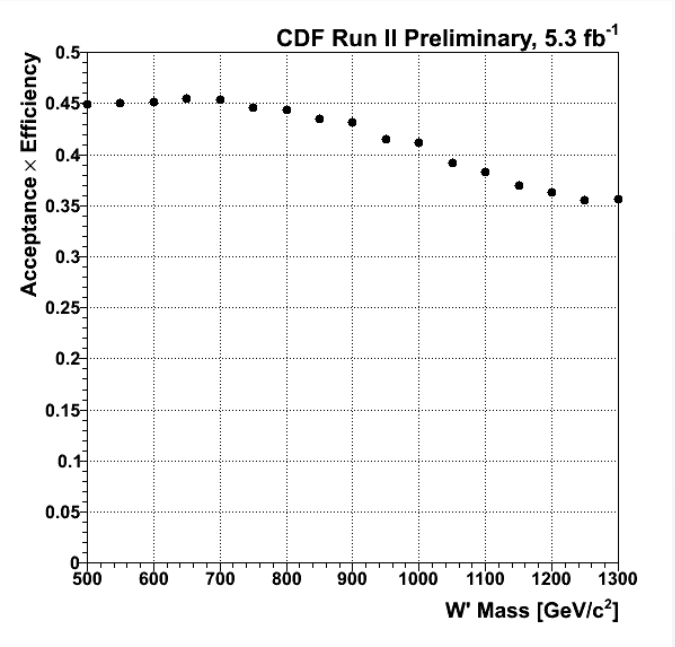
- W' boson appears in breaking symmetry of $SU(2)_R \times SU(2)_L \times U(1)_{B,L}$
- Search for W'->eν_e
- Require
- Isolated electron with E_T > 25 GeV
- An additional trigger at E_T > 70 GeV to increase electron efficiency
- MET > 25 GeV
- To reduce QCD background:

  $0.4 < E_T / MET < 2.5$

W' Search

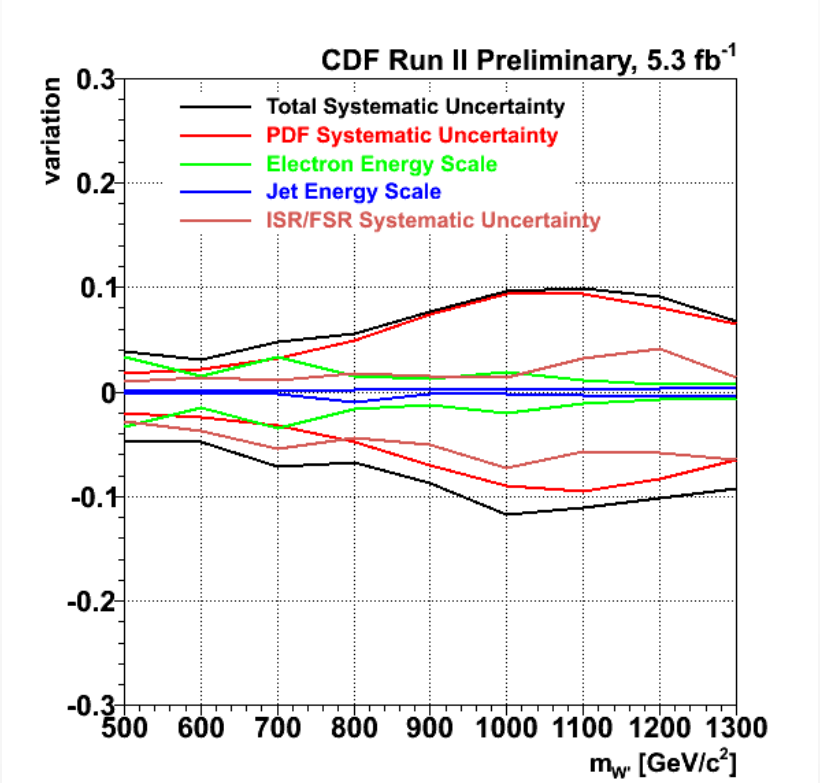


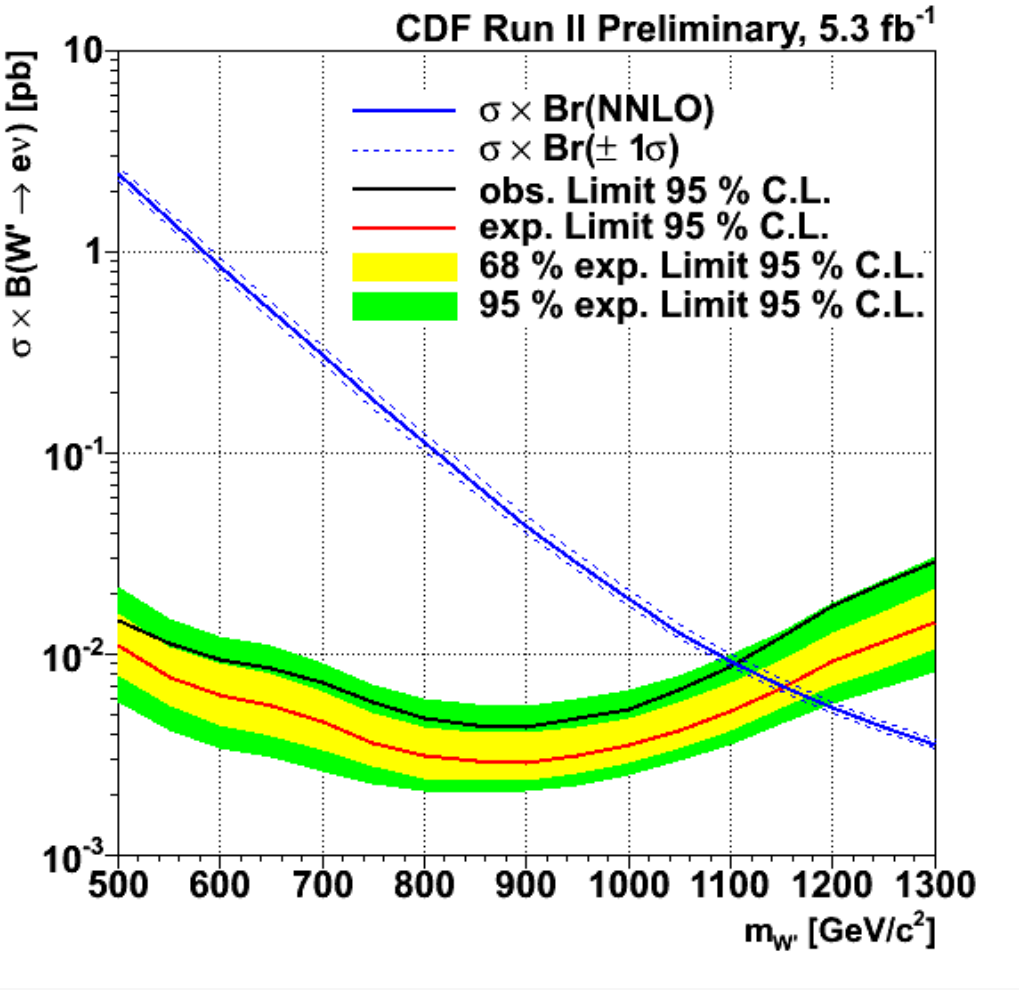
- Assume that W' V+A coupling are of the same strength as V-A
- Transverse mass distribution smeared for high-mass bosons due to smallness of PDFs
- Acceptance drops at high masses due to inefficiency of ultra-high E_T electrons (E_T > 500 GeV)



W' Search

- Perform a binned likelihood fit to a combination of background and signal
- Systematic uncertainties are dominated by PDF



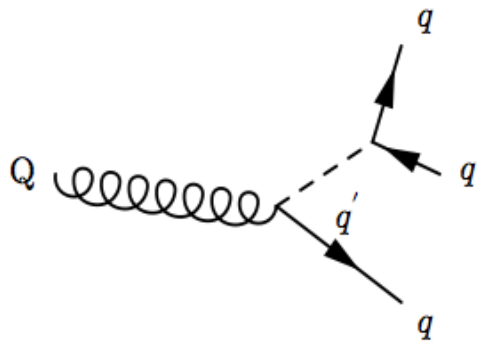


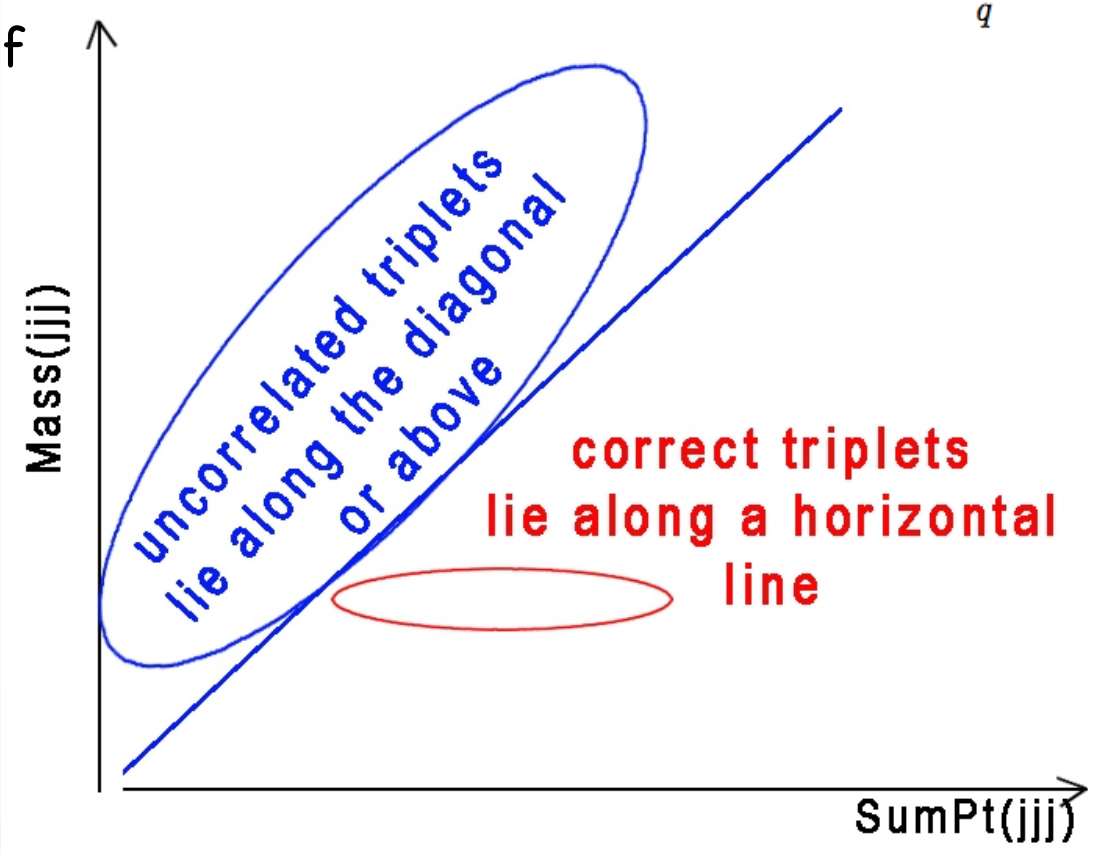
- Exclude m(W') < 1.1 TeV at 95%C.L.
- arXiv: 1012.5145

Search for 3-jet Resonances

- Search for pp->QQ -> 3j + 3j
  (final state with 6 or more jets)
- Look at all possible combinations in an multijet
- Each event has an "ensemble" of 20 or more triplets

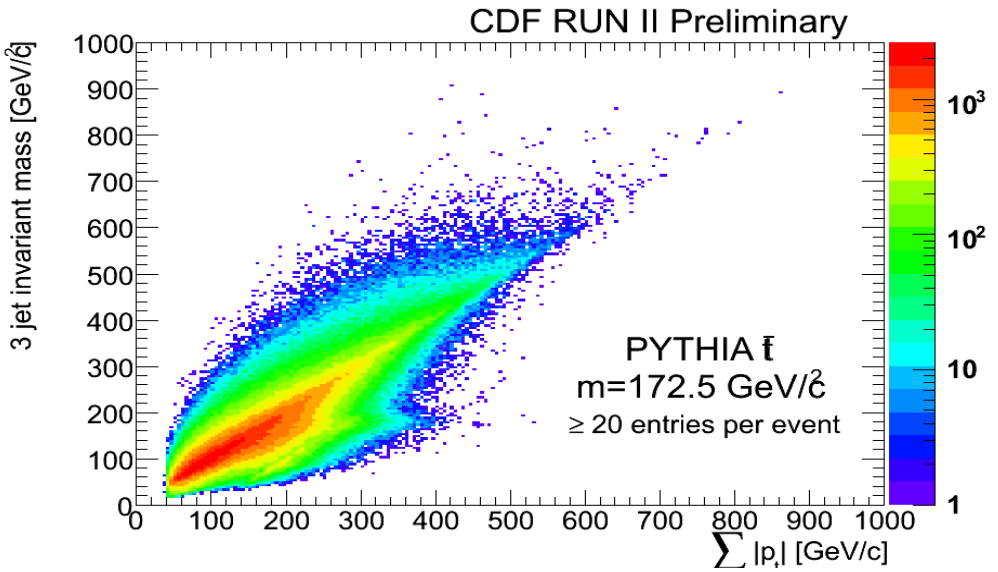
- Event Selection:
- At least 6 jets
  with p_T > 15 GeV/c
  from the same vertex
- Σ_6 p_T > 250 GeV/c
- Missing E_T < 50 GeV



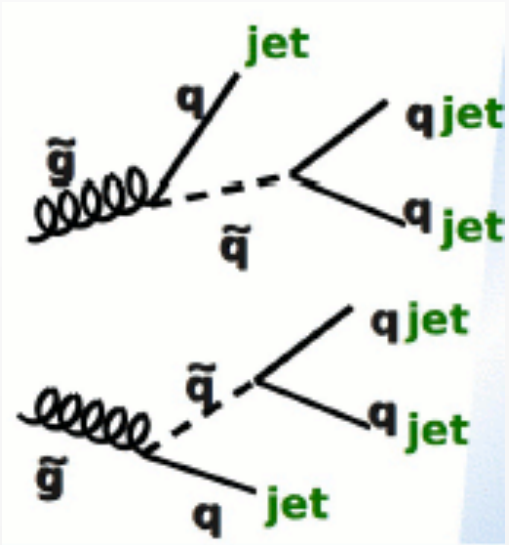


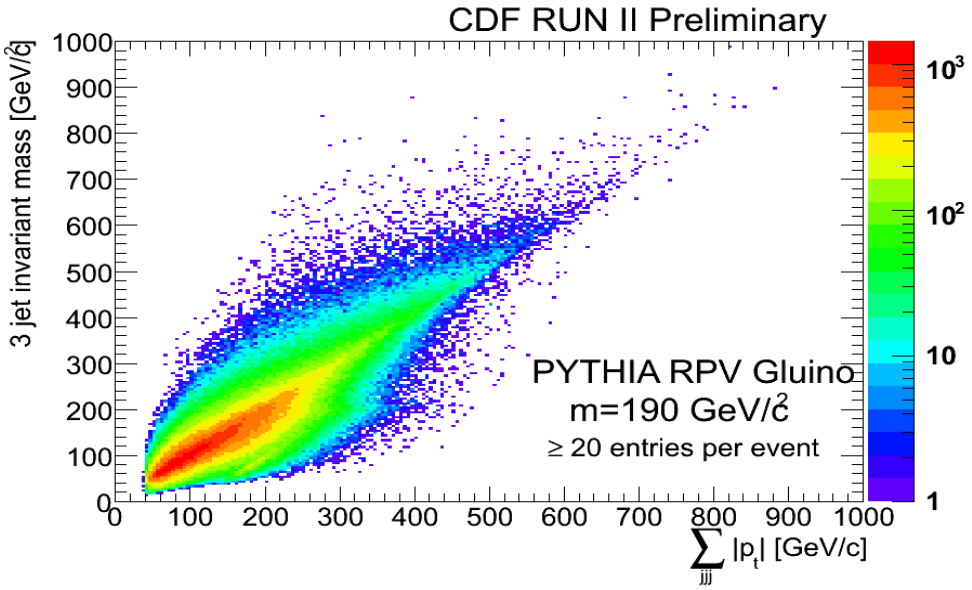
Search for 3-jet Resonances

- Signal examples: tt



- RPV gluino:



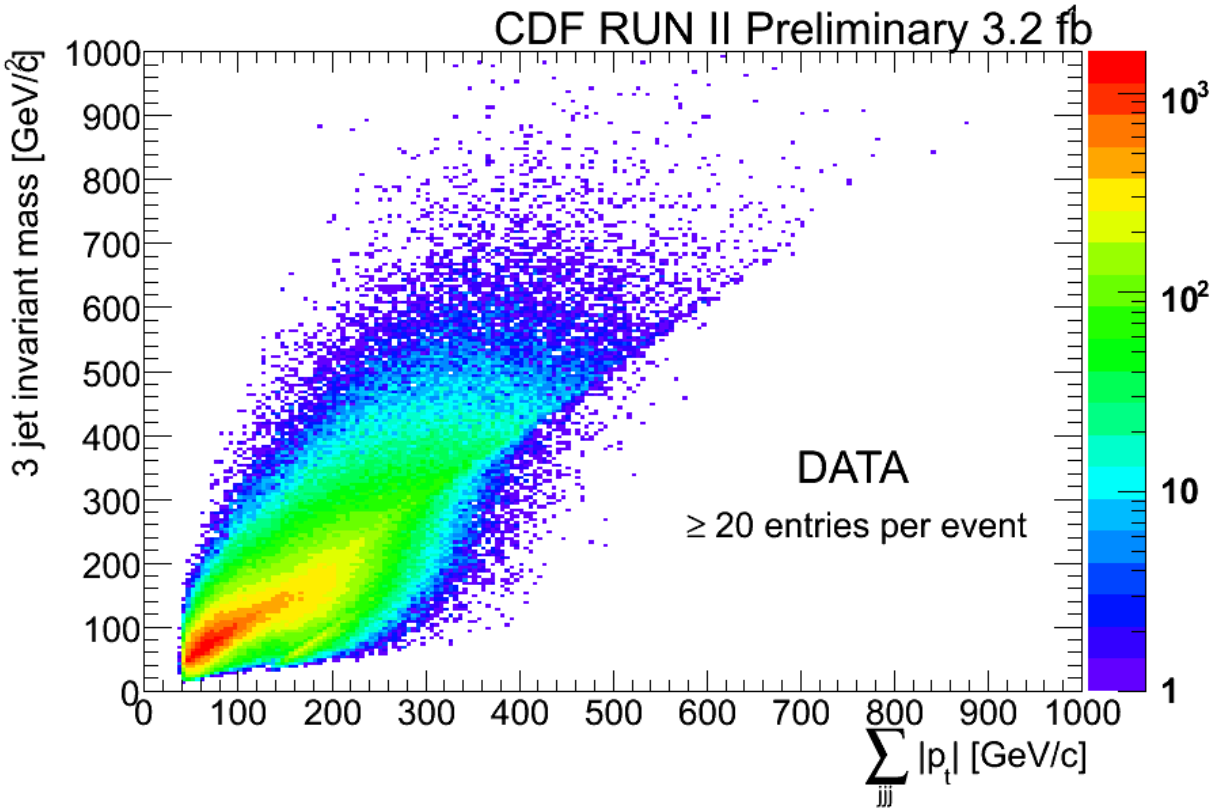


Search for 3-jet Resonances

- Analysis strategy:
- Apply diagonal cut:
- $\Sigma_{3j}\ p_T - m(jjj) > \alpha$

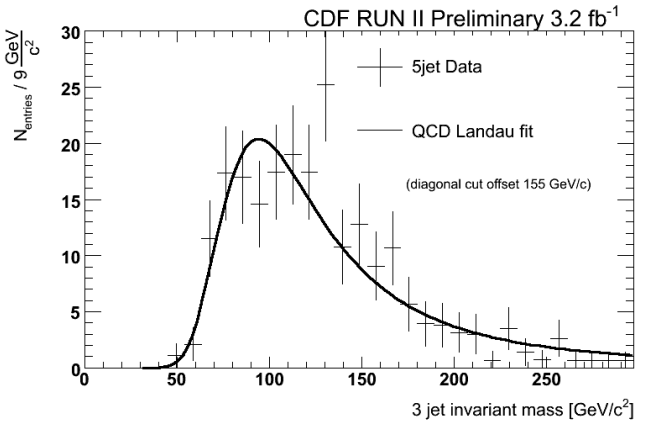
Optimized for each gluino mass

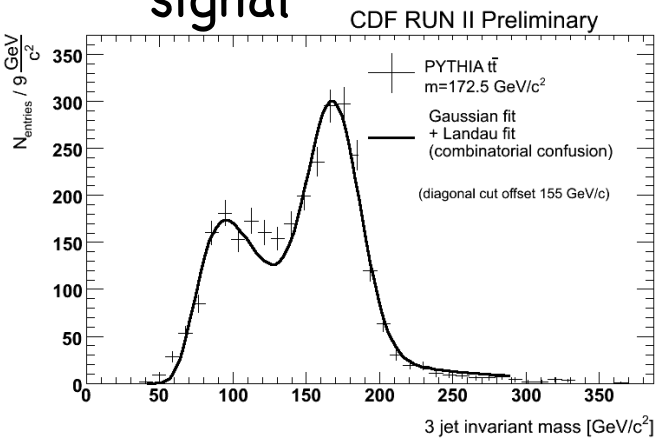
- Fit the final mass cut
- Use statistically independent 5-jet sample to model QCD background (Landau-shape)
- Signal is a combination of Gaus (correct triplet combination) and Landau (wrong combination)



Search for 3-jet Resonances

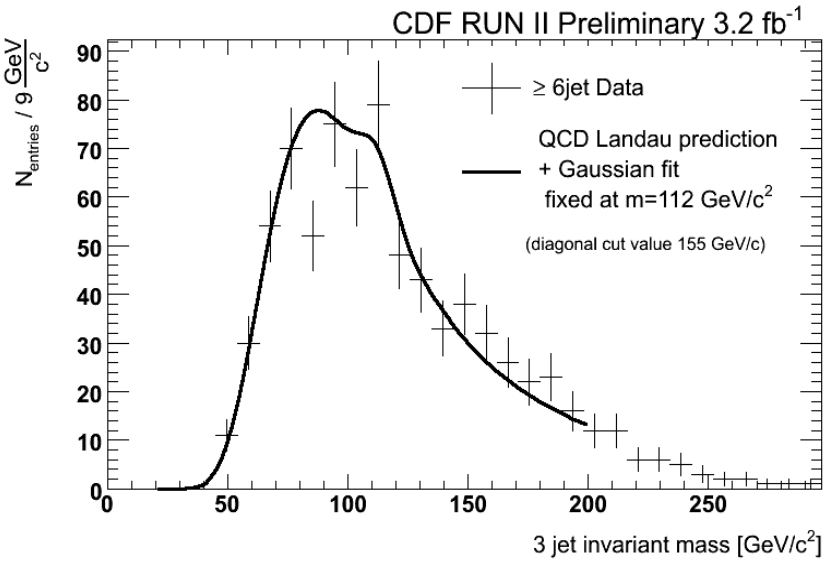
- Fit : QCD + signal

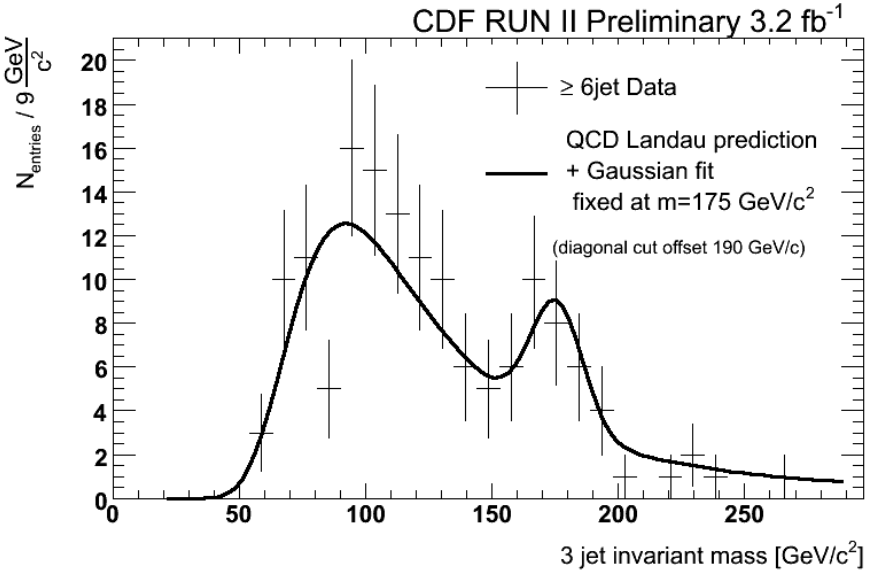




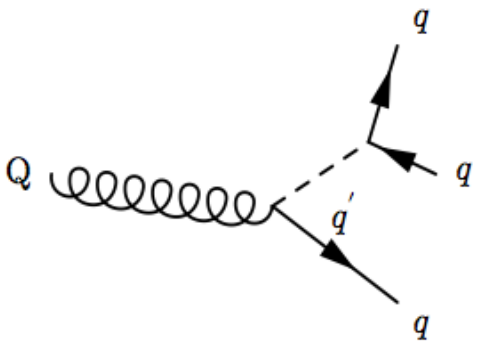
For various diagonal offset cuts

- Data Results:

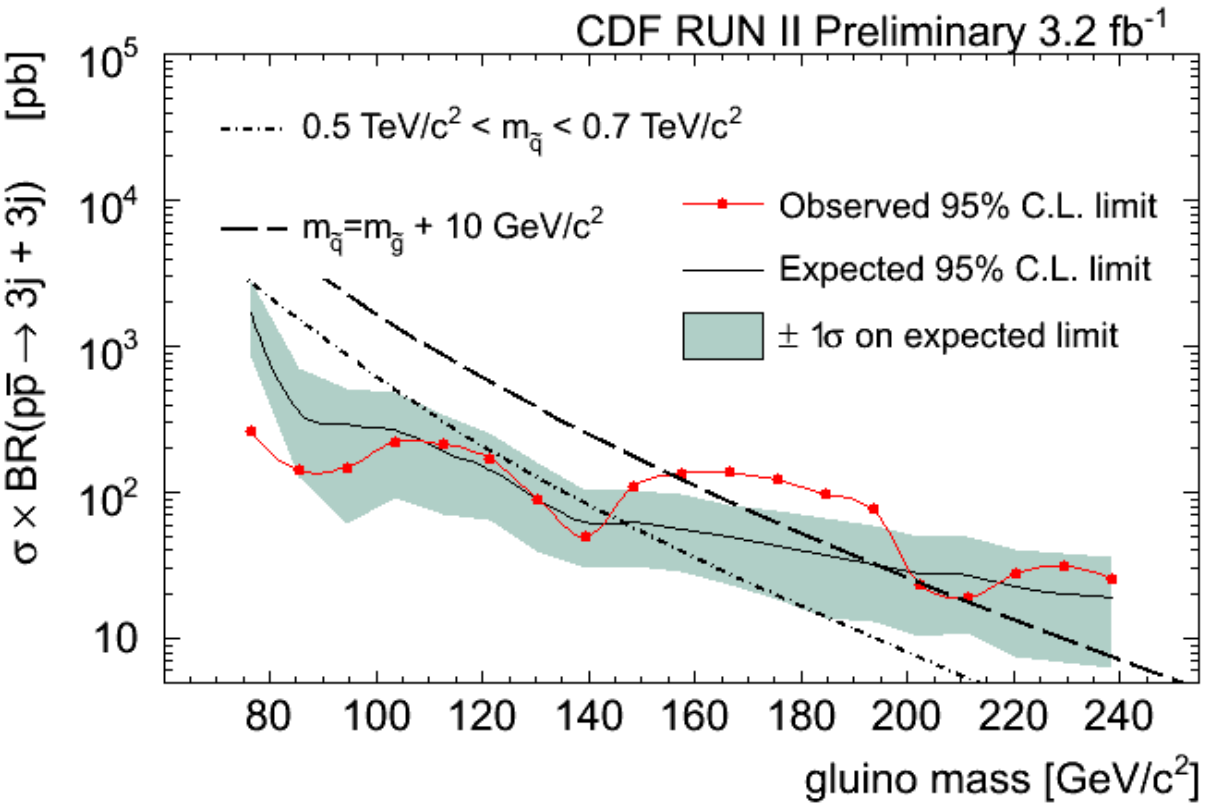




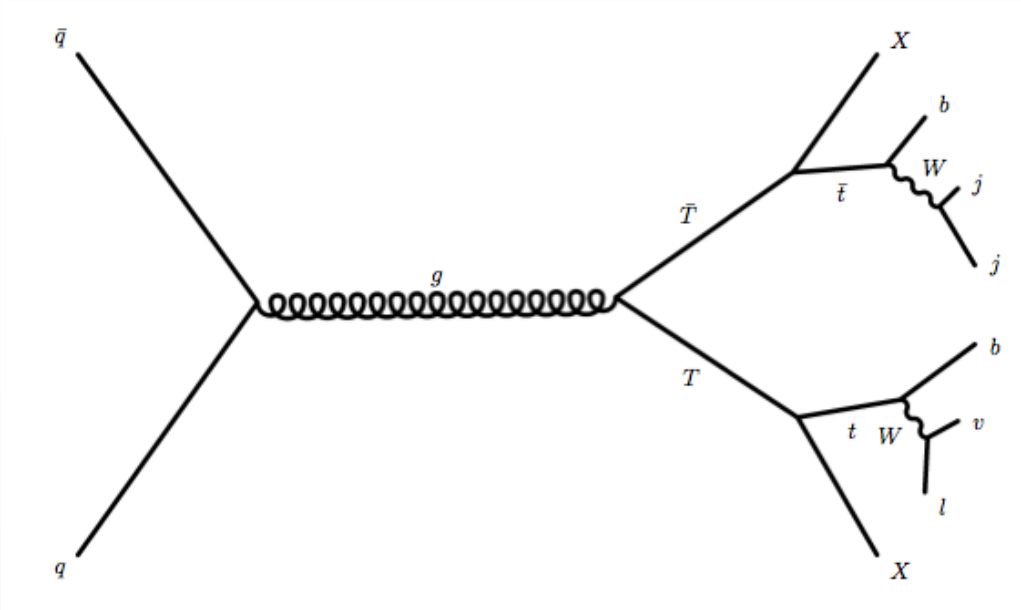
Search for 3-jet Resonances



- For benchmark scenario exclude gluino mass below 144 GeV



Search for T'->tX

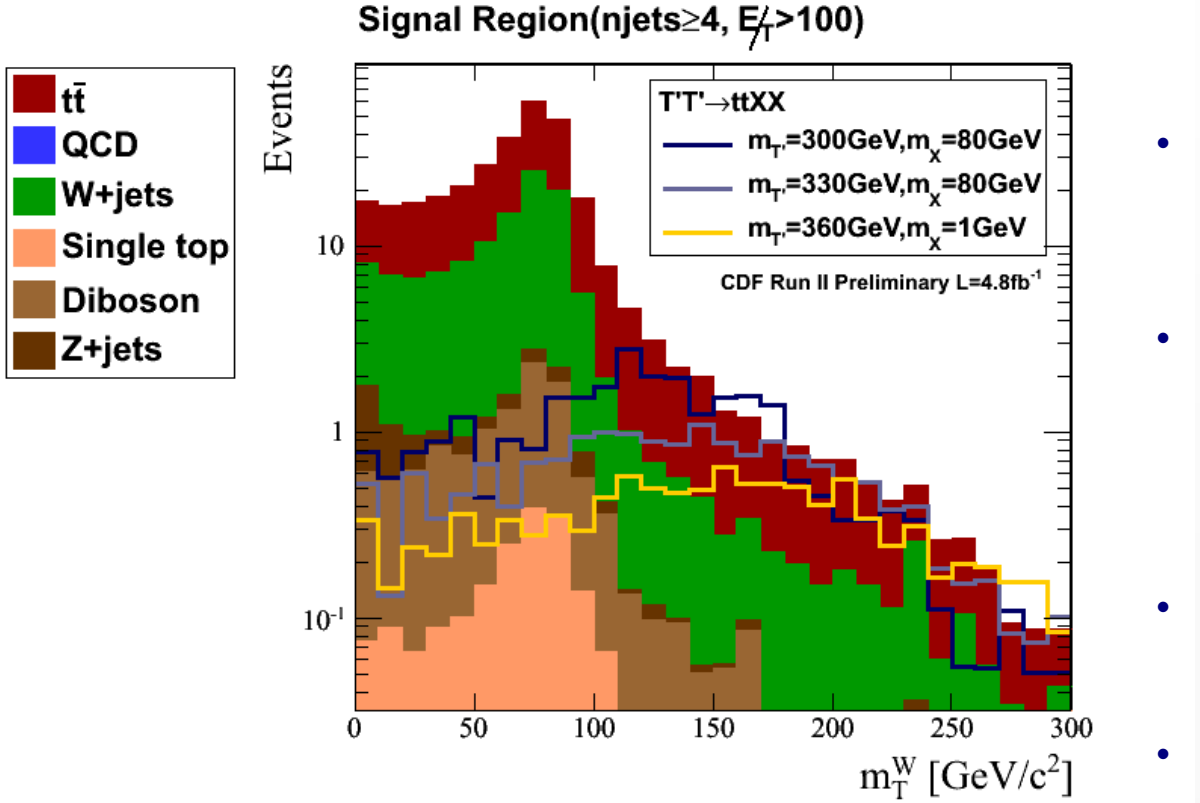


- Exotic 4-th generation quarks t'-> tX, where X is a dark matter candidate
- J.Feng et al, arXiv:1002.3366
- Other scenario:
  - stop -> top + neutralino

- Signature tt + MET
- Select e OR μ with p_T > 20 GeV
- >=4 jets , E_T > 20 GeV
- MET > 100-160 GeV

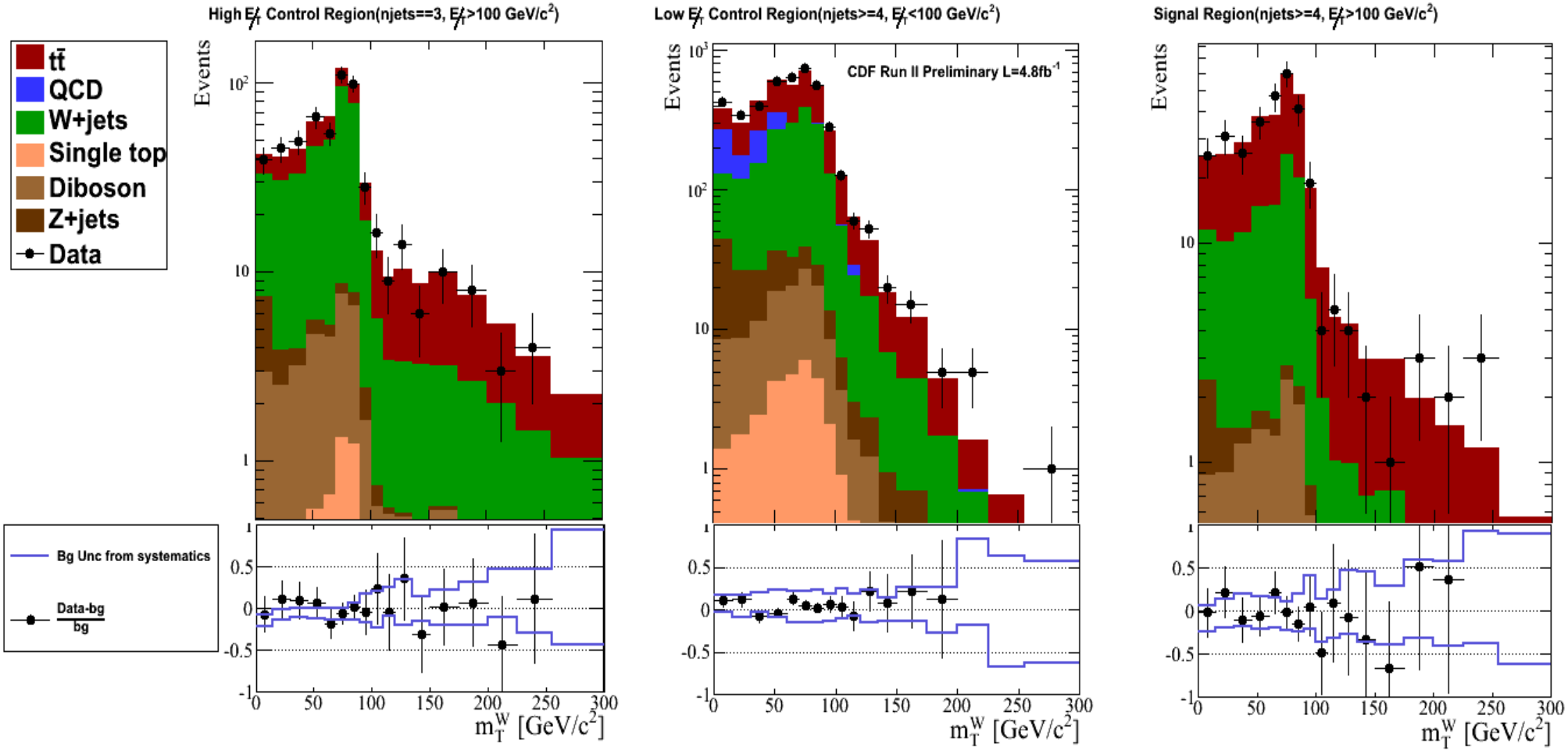
- Dominant backgrounds are tt and W+jets

Search for T'->tX



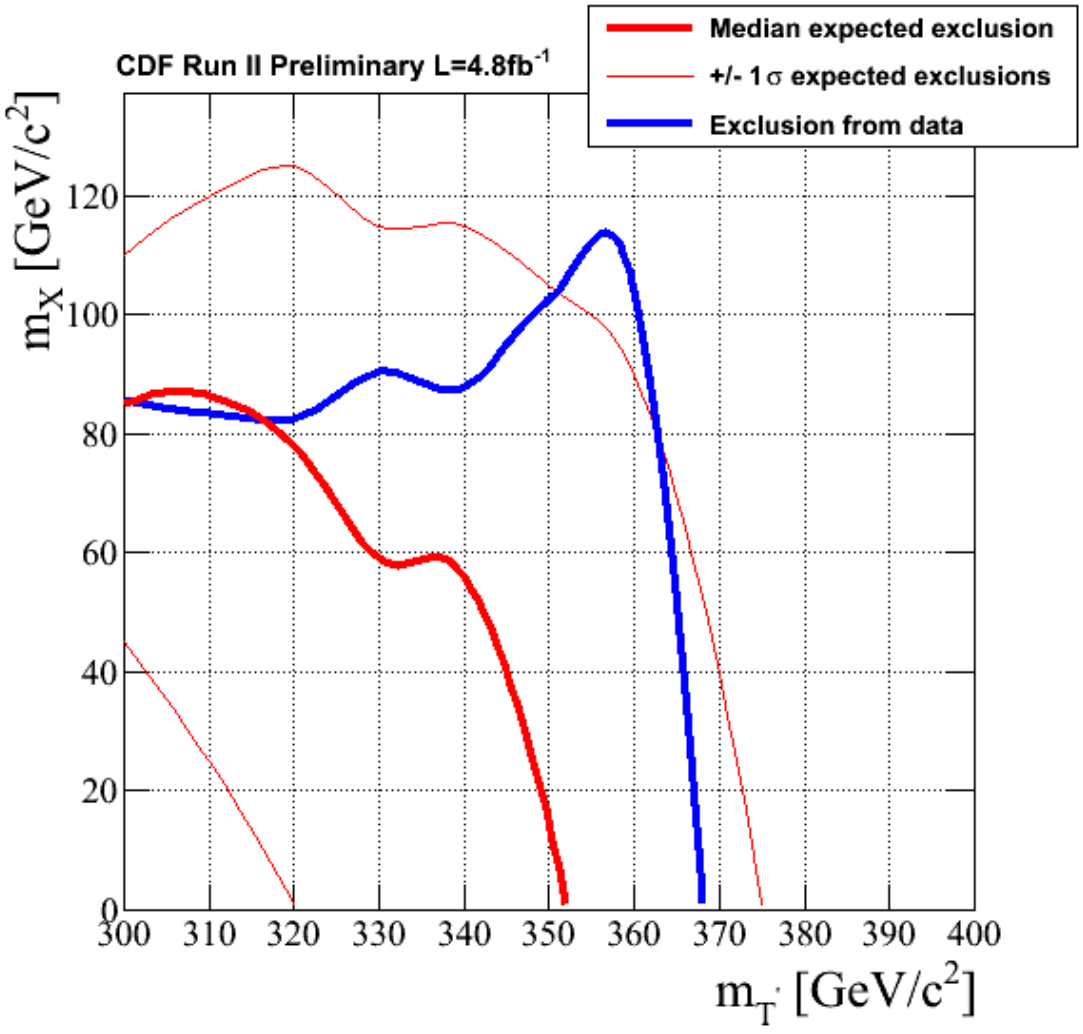
- Analysis: Fit background + signal to W transverse mass distribution
- Optimize MET cut using S/√B for each new physics point in ($m_{T'}$, m_X) plane
- Observe 309 events for MET > 100 GeV
- Expect 310 ± 80 from SM
- For MET > 150 GeV
- 42 data events (45± 14 exp.)

Search for T'->tX



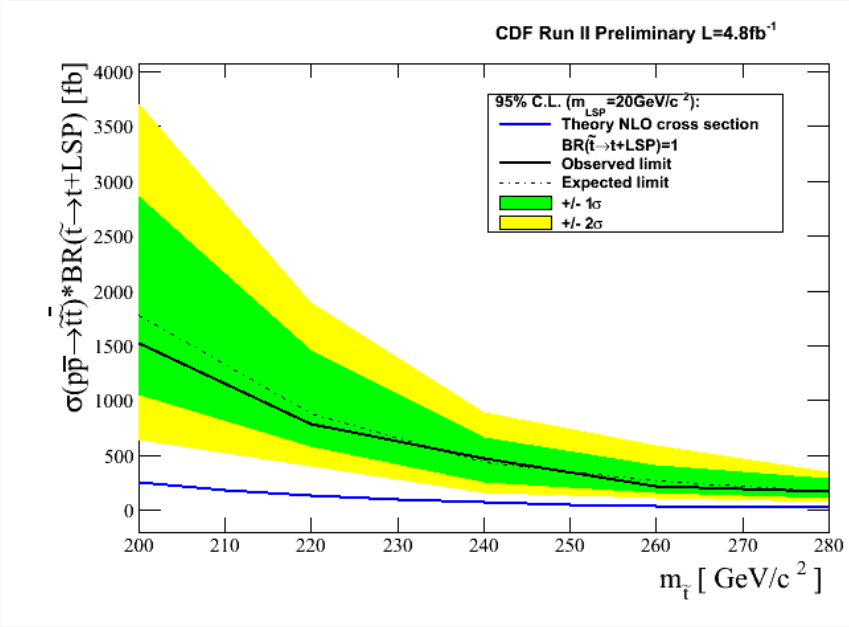
- Test modeling of distributions in control regions (= 3jets, low MET)

Search for T'->tX

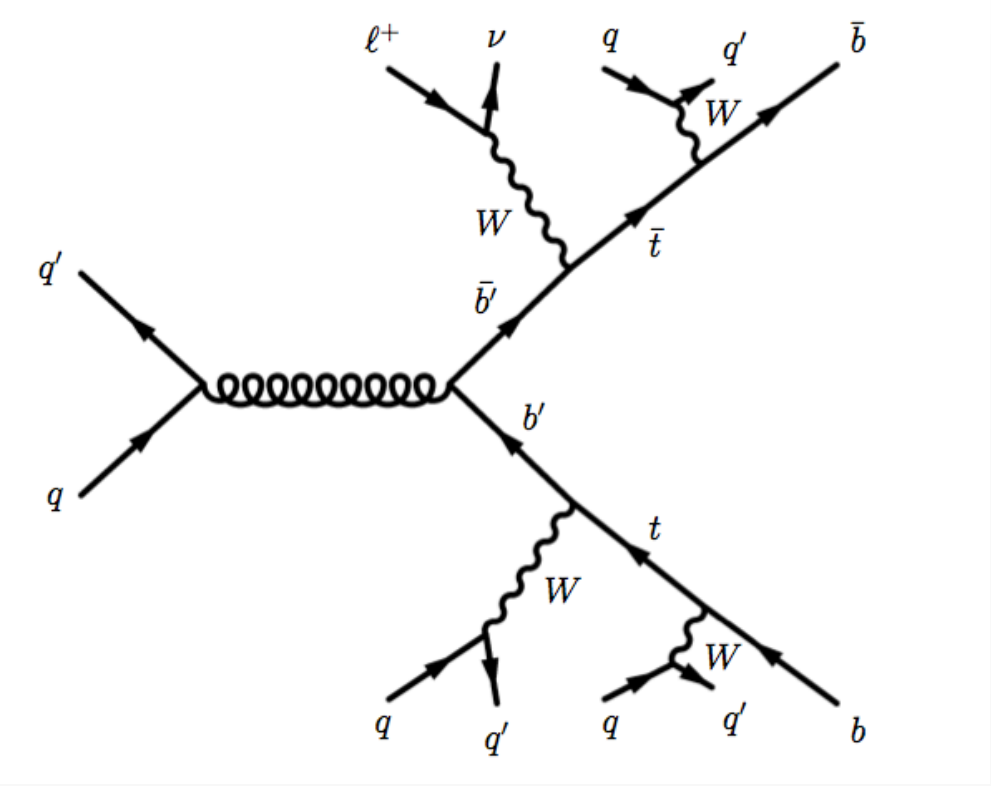


- Scan 2D-plane of ($m_{T'}$, m_X)
- Set a 95% limit using Neuman construction

- No sensitivity to supersymmetric top due to small cross section

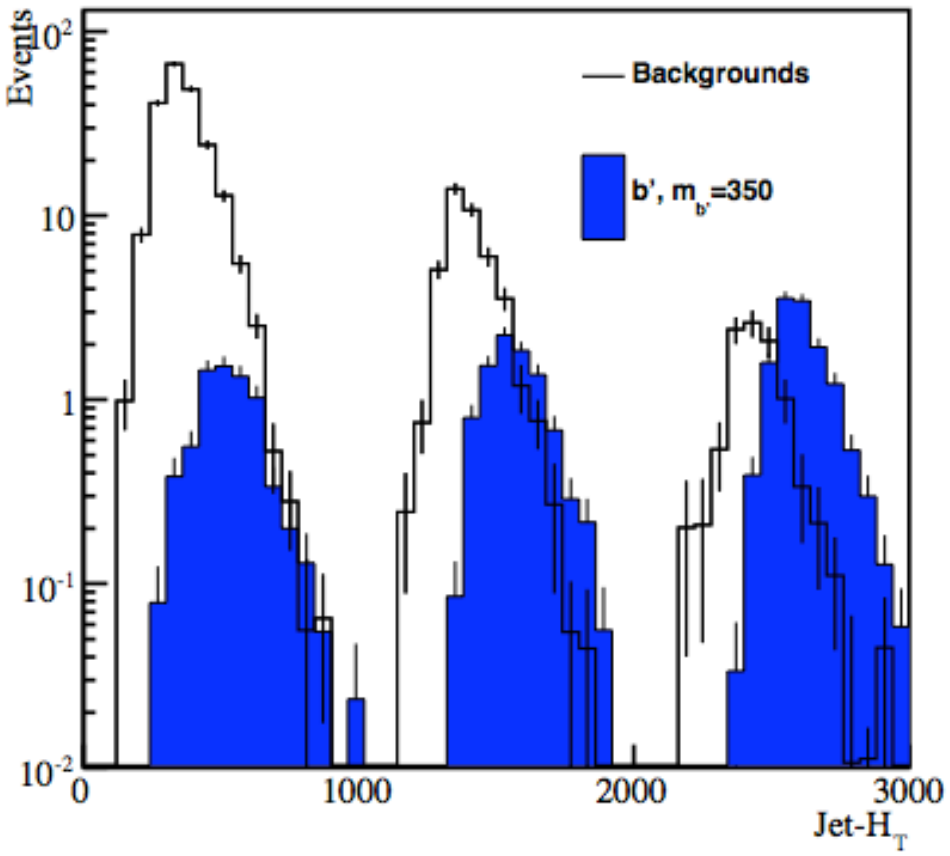


Search for b'->tW



- Current limits push 4-th generation down-type quark b' to be above m(t)+ m(W) mass
- Electroweak precision measurement suggest small mass splitting between 4-th generation t' and b', if exist
- Search for b'-> tW at CDF was previously performed using same-sign lepton events
- New search uses "lepton+jets" signature
- High acceptance due to hadronically decaying W's

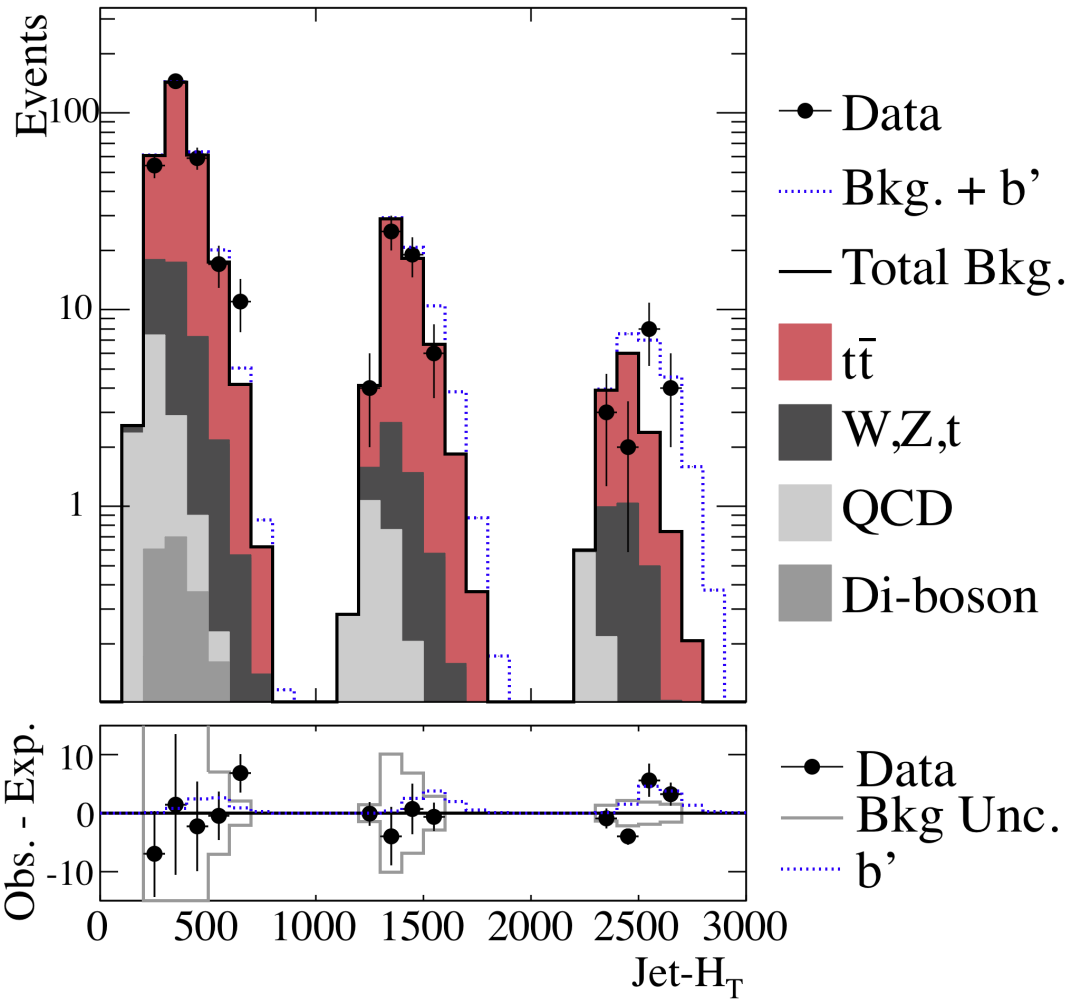
Search for b'->tW



5 Jets 6 Jets ≥7 Jets

- Search for b'b'-> ttWW by fitting to
- H_T = scalar Σ (Jet E_T + lepton E_T + MET) across different jet multiplicity bins

Search for b'->tW



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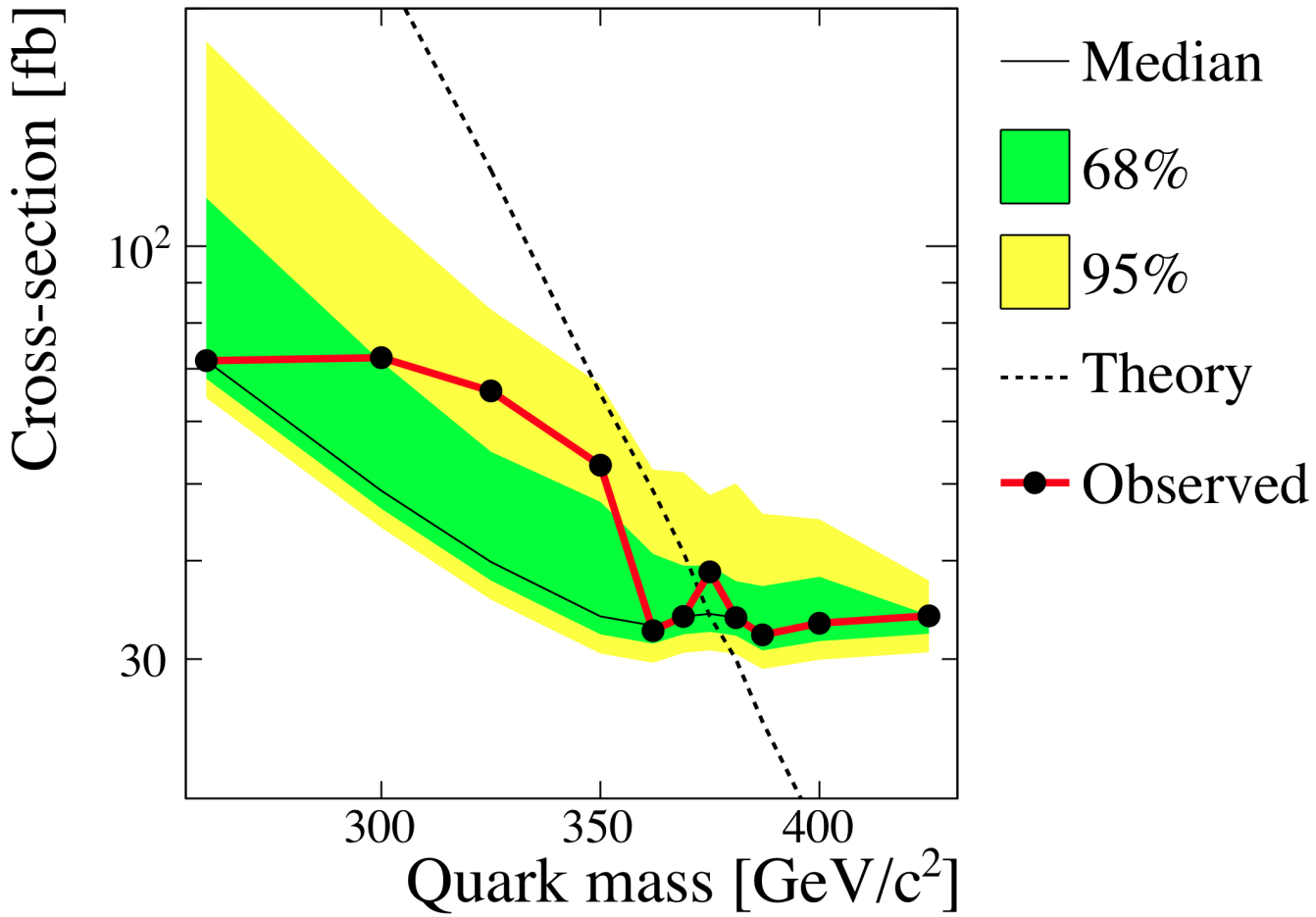
Search for b'->tW



- Exclude b' quark below 385 GeV at 95%C.L.
- arXiv: 1101.5728

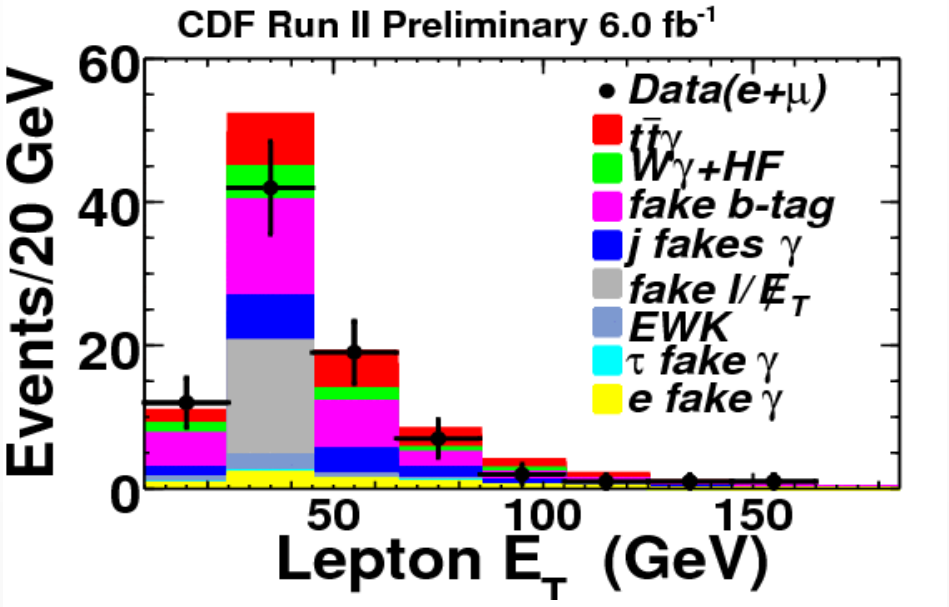
Search for anomalous lbγMET and measurement of ttγ

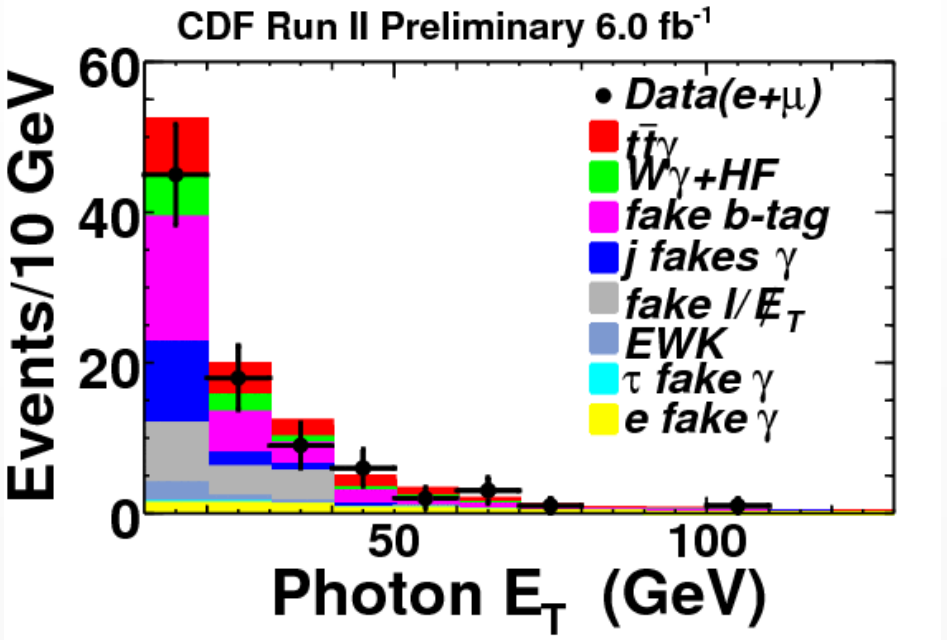
CDF Run II, 6.0 fb^{-1}			
Lepton + Photon + $\not\!\!E_T$ + b Events, Isolated Leptons			
Standard Model Source	$e\gamma b\not\!\!E_T$	$\mu\gamma b\not\!\!E_T$	$(e+\mu)\gamma b\not\!\!E_T$
$t\bar{t}\gamma$ semileptonic	6.74 ± 1.24	5.91 ± 1.08	12.65 ± 2.29
$t\bar{t}\gamma$ dileptonic	3.90 ± 0.71	3.39 ± 0.62	7.29 ± 1.32
$W^{\pm}c\gamma$	2.29 ± 0.45	2.42 ± 0.47	4.71 ± 0.73
$W^{\pm}c\bar{c}\gamma$	0.25 ± 0.11	0.75 ± 0.22	1.00 ± 0.24
$W^{\pm}b\bar{b}\gamma$	1.92 ± 0.32	1.46 ± 0.27	3.38 ± 0.48
WZ	0.23 ± 0.10	0.089 ± 0.07	0.31 ± 0.12
WW	0.29 ± 0.07	0.26 ± 0.06	0.55 ± 0.10
Single Top (s-chan)	0.54 ± 0.24	0.46 ± 0.22	1.00 ± 0.34
Single Top (t-chan)	1.13 ± 0.45	0.83 ± 0.38	1.96 ± 0.61
$\tau \to \gamma$ fake	0.37 ± 0.11	0.37 ± 0.11	0.74 ± 0.17
Jet faking γ ($ej\not\!\!E_T b, j \to \gamma$)	8.88 ± 2.57	5.28 ± 1.67	14.16 ± 3.85
Mistags	17.37 ± 1.71	12.02 ± 1.18	29.43 ± 2.75
QCD(Jets faking ℓ and $\not\!\!E_T$)	14.39 ± 7.33	1.44 ± 0.73	15.83 ± 7.38
$ee\not\!\!E_T b$, $e \to \gamma$	4.86 ± 0.71	–	4.86 ± 0.71
$\mu e\not\!\!E_T b$, $e \to \gamma$	–	1.32 ± 0.23	1.32 ± 0.23
Total SM Prediction	$63.2 \pm 8.1(tot)$	$36.0 \pm 2.6(tot)$	$99.1 \pm 9.3(tot)$
Observed in Data	51	34	85

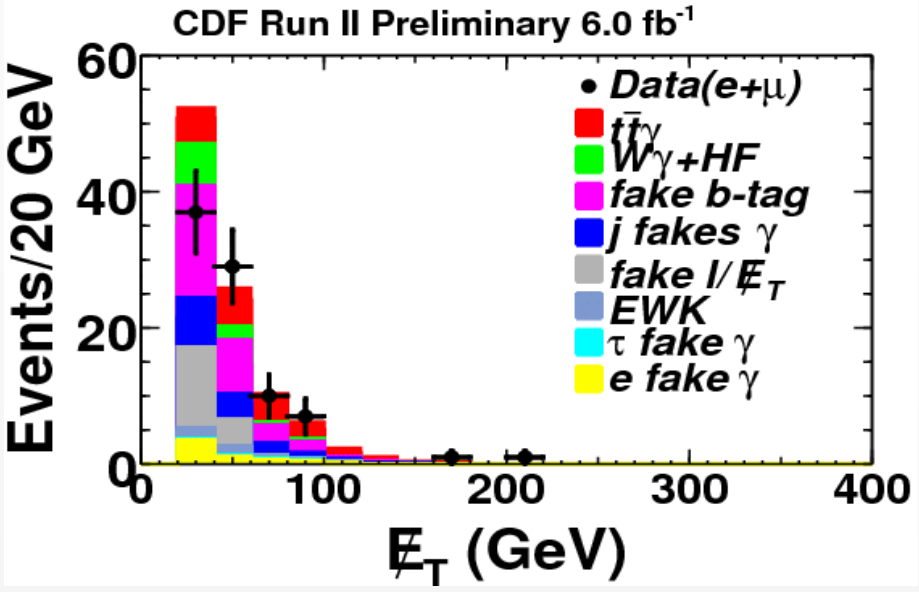
- Signature-based search for anomalous rates or kinematics
- Poissible new physiscs scenario is GMSB
- Select e OR μ with p_T > 20 GeV
- >=1 jets , E_T > 15 GeV
- (at least one b-tagged)
- MET > 20 GeV
- γ, E_T > 10 GeV

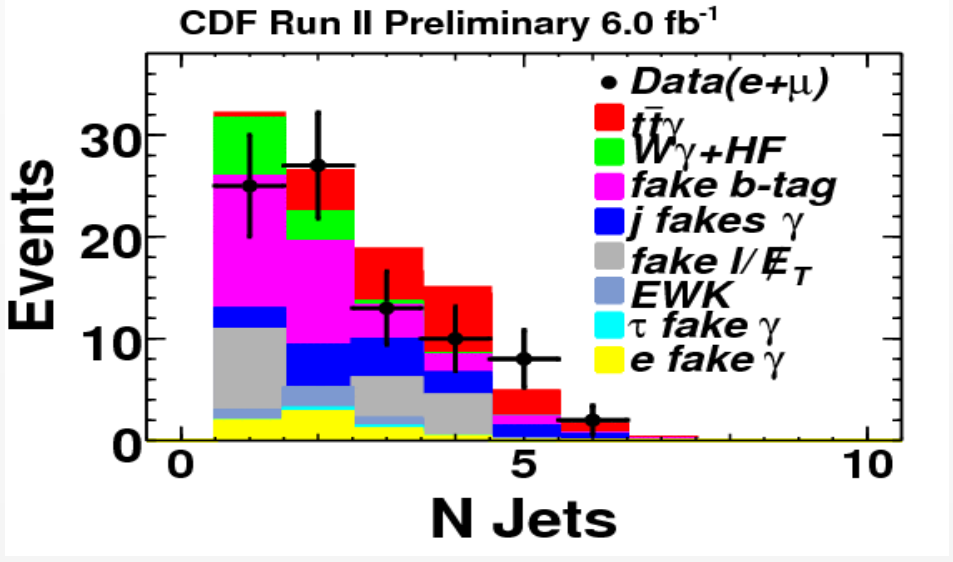
- Many backgrounds are evaluated using data-driven techniques and tested using control samples

Search for anomalous lbγMET and measurement of ttγ







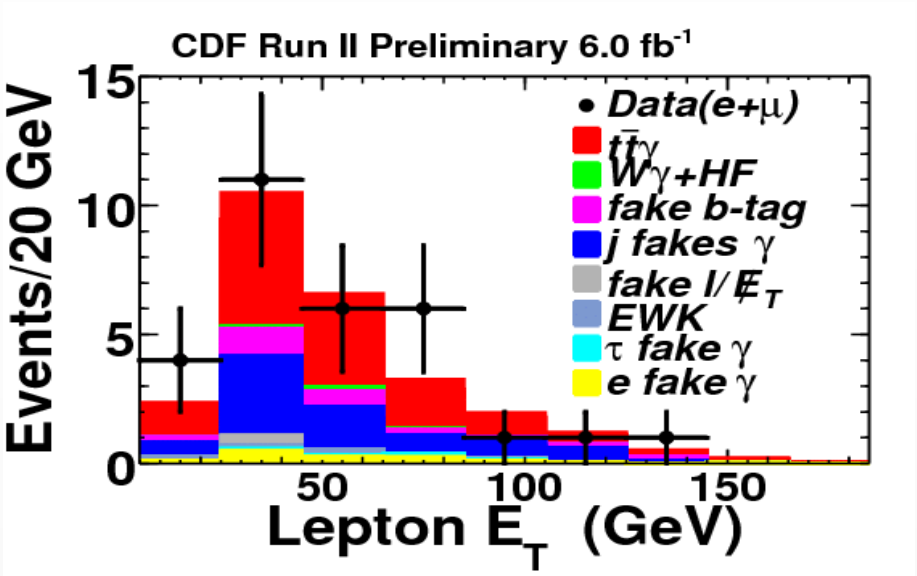


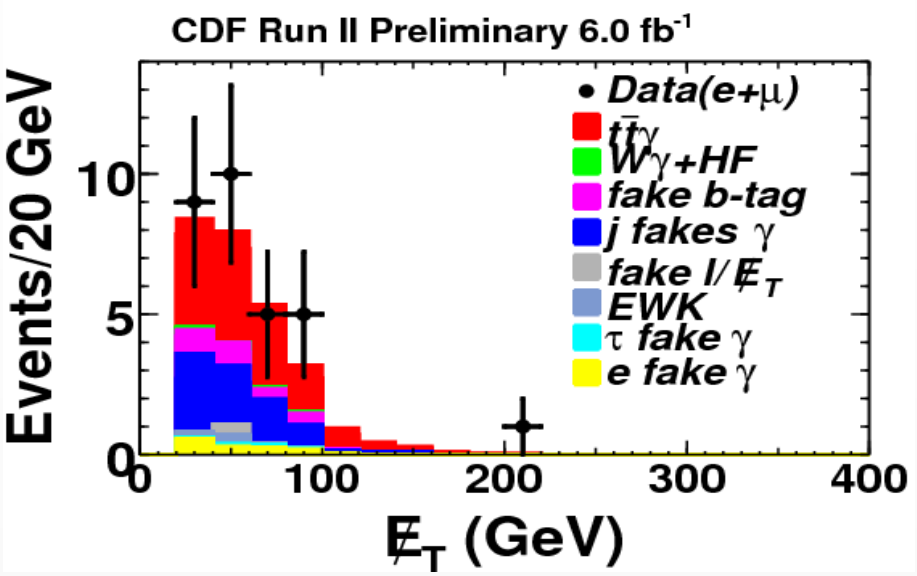
Search for anomalous lbγMET and measurement of ttγ

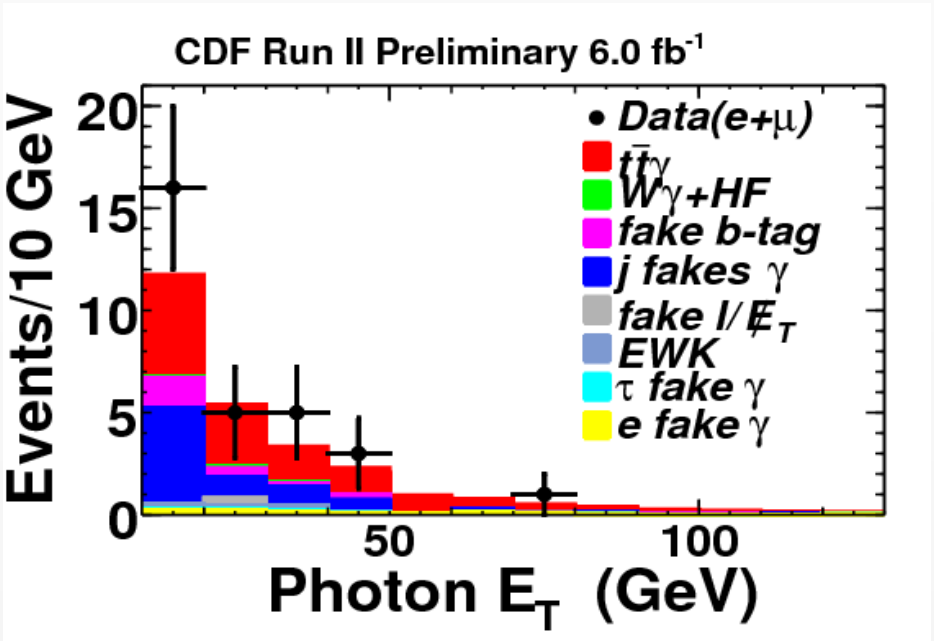
CDF Run II, 6.0 fb^{-1}			
$t\bar{t}\gamma$, Isolated Leptons, Tight Chi2 on Photons			
Standard Model Source	$e\gamma b\not\!\!E_T$	$\mu\gamma b\not\!\!E_T$	$(e+\mu)\gamma b\not\!\!E_T$
$t\bar{t}\gamma(semileptonic)$	5.98 ± 1.10	5.21 ± 0.97	11.19 ± 2.04
$t\bar{t}\gamma(dileptonic)$	1.47 ± 0.27	1.27 ± 0.24	2.74 ± 0.50
$W^{\pm}c\gamma$	0 ± 0.07	0 ± 0.07	0 ± 0.09
$W^{\pm}c\bar{c}\gamma$	0 ± 0.05	0.05 ± 0.05	0.05 ± 0.07
$W^{\pm}b\bar{b}\gamma$	0.15 ± 0.07	0.06 ± 0.05	0.21 ± 0.08
WZ	0.05 ± 0.05	0.05 ± 0.05	0.09 ± 0.06
WW	0.06 ± 0.03	0.06 ± 0.03	0.11 ± 0.03
Single Top (s-chan)	0.09 ± 0.10	0 ± 0.10	0.09 ± 0.13
Single Top (t-chan)	0.14 ± 0.14	0.13 ± 0.14	0.27 ± 0.19
$\tau \to \gamma$ fake	0.20 ± 0.08	0.10 ± 0.05	0.29 ± 0.09
Jet faking γ ($ej\not\!\!E_T b, j \to \gamma$)	5.75 ± 1.76	1.79 ± 1.56	7.54 ± 2.53
Mistags	1.47 ± 0.37	1.02 ± 0.32	2.50 ± 0.51
QCD(Jets faking ℓ and $\not\!\!E_T$)	0.38 ± 0.38	0.02 ± 0.020	0.40 ± 0.38
$ee\not\!\!E_T b$, $e \to \gamma$	0.94 ± 0.19	–	0.94 ± 0.19
$\mu e\not\!\!E_T b$, $e \to \gamma$	–	0.49 ± 0.11	0.49 ± 0.11
Total SM Prediction	$16.7 \pm 2.2(tot)$	$10.3 \pm 1.9(tot)$	$26.9 \pm 3.4(tot)$
Observed in Data	17	13	30

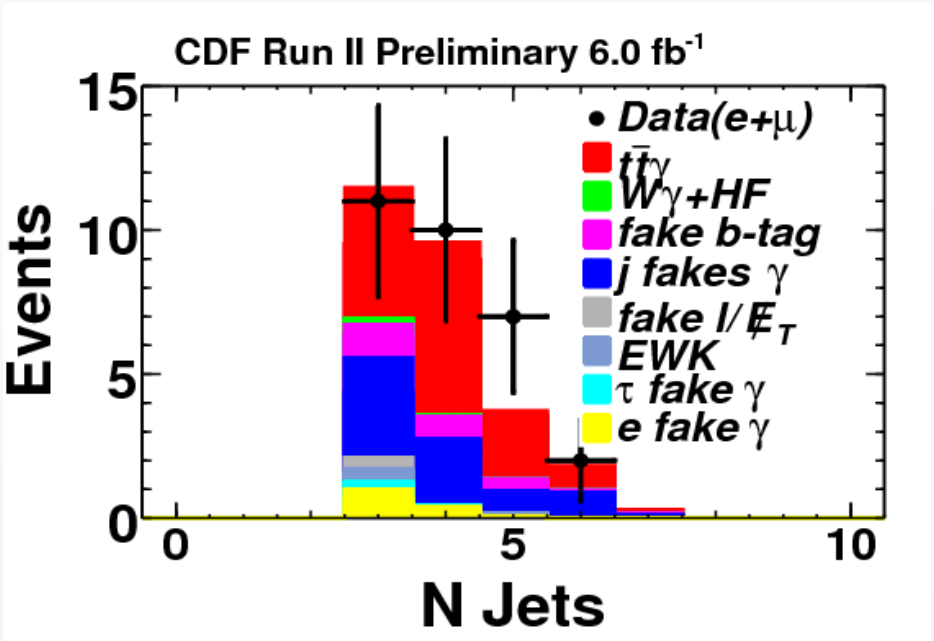
- Select tt events applying an additional H_T > 200 GeV
- >=3 jets , E_T > 15 GeV
- (at least one b-tagged)
- The largest contributing process is ttγ
- Good agreement with SM predictions

Search for anomalous lbγMET and measurement of ttγ

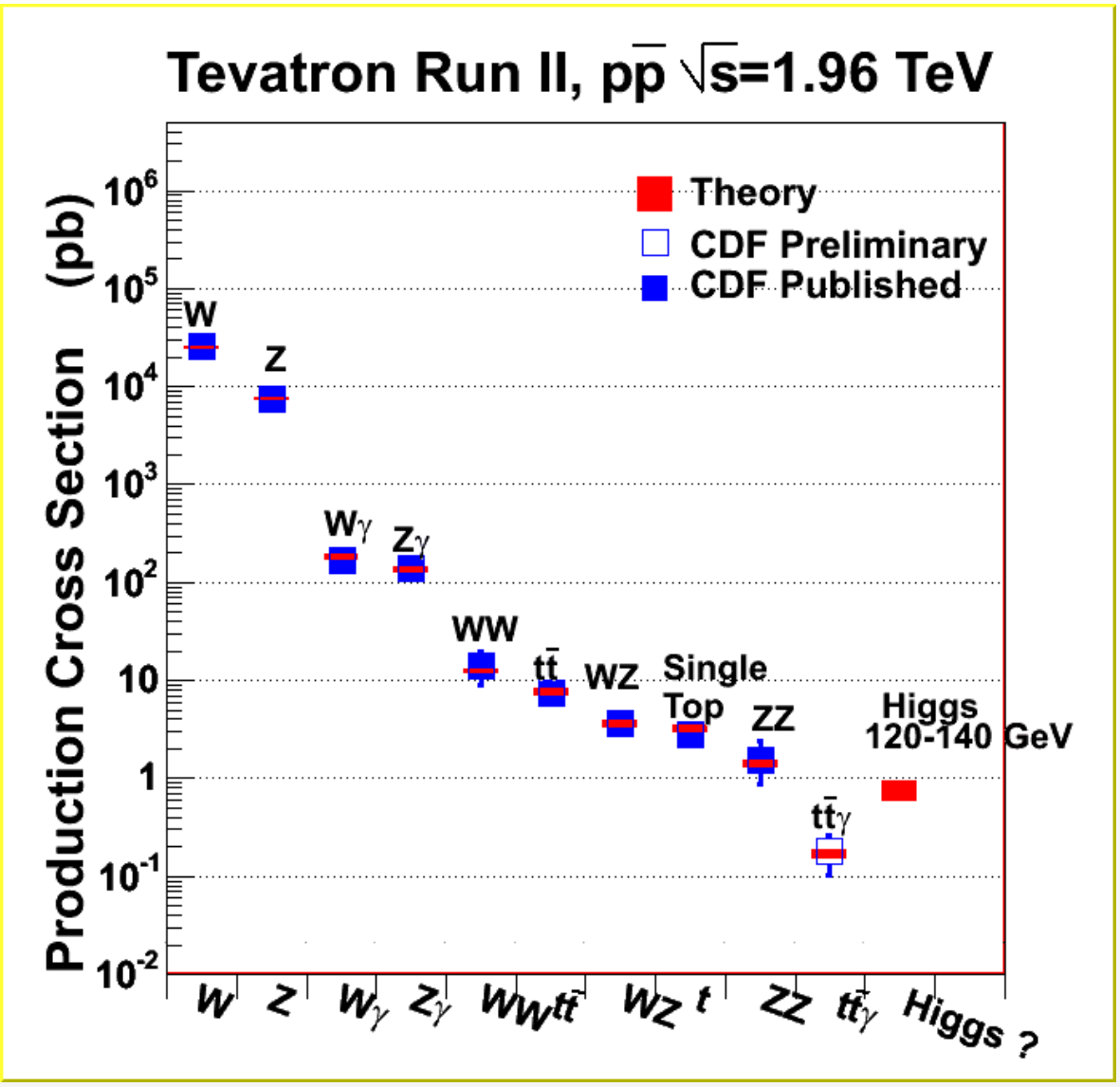








Search for anomalous lbγMET and measurement of ttγ



- Measure ttbar+γ cross section
  0.18 ± 0.07 pb
- In agreement with SM
  0.17 ± 0.03 pb

Summary

- Tevatron continues taking data

  and continues to push
  - for better/improved limits on new particle production and
  - exercises more advanced techniques that are applicable and being applied at LHC

- More details about these and other results are available at:
  - http://www-cdf.fnal.gov/physics/physics.html